The Influence of Bubbles on High-Frequency Acoustics in Shallow Water

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LONG-TERM GOALS

The long-term goal of the overall program, of which this project is a part, is to develop the ability to predict the effects of bubbles on the operation of high-frequency acoustic systems in shallow water to support MCM and Special Warfare applications.

OBJECTIVES

The scientific objectives of this project are to understand the populations, dynamics, and persistence of bubbles produced by surf and wind in very shallow water coastal regions and to establish their effects on high-frequency acoustic systems that might operate there.

APPROACH

In the Spring of 1997, an experiment into the effects of bubbles on high-frequency acoustic systems was performed just offshore from active surf. The experiment was a part of a research effort sponsored by the Office of Naval Research (ONR). The site of the experiment was just north of the pier at the Scripps Institution of Oceanography (SIO) in La Jolla, CA. A wide range of coastal oceanography and acoustic measurements were taken by several principal investigators from a number of organizations. The Naval Research Laboratory (NRL) led the overall operation and conducted its own set of measurements to contribute to the coordinated effort. The NRL measurements involved a triangular frame with 10-m sides called the "Delta Frame." The Delta Frame was capable of making attenuation and travel-time measurements at eight frequencies from 39 to 248 kHz over 16 paths within a 70-square meter horizontal patch of water at a depth of about 4 m. From these data sound speed dispersion and bubble populations were calculated and inhomogeneous bubble clouds were tomographically reconstructed at a scale of 2 m.

In 1995 an initial experiment was preformed by NRL off the coast of Panama City, FL, as a forerunner to the more elaborate experiment at the Scripps Pier. The initial experiment set some of the parameters and posed questions to be answered by the wider group in the second more comprehensive experiment. An important result of that initial experiment was to establish the need and set the stage for measurements of effects due to bubbles down to smaller radii than previously thought of interest. That experiment also established the need for a wider range of measurements, all of which were brought to bear at the Scripps Pier in 1997.

In addition to the Principal Investigator listed above, Dr. Steve Stanic was the on-scene director of all operations, including NRL participants and PIs from other institutions (listed in section on Related Projects). NRL group consisted of divers, specialized

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technical personnel, and contractor support personnel. Additionally, closely associated with the NRL investigators were Dr. Paul Elmore, a Post Doc Fellow, and Dr. Ralph Goodman, an IPA assigned to NRL

WORK COMPLETED
The work completed in FY97 was the Scripps Pier Bubble Experiment and selected analyses.

RESULTS
A major accomplishment of the experiment was its wide range of coordinated measurements. These measurements have provided insights into the generation, movement, spatial and temporal extent, and decay of bubble patches created in active surf and carried offshore by rip currents. Dramatic bubble effects were observed by each investigator on his own specialized instruments, and the collection of instruments presented a consistent picture of the bubble field dynamics.

IMPACT/APPLICATIONS
This was the first work that demonstrated the dramatic bubble effects produced by active surf and carried offshore in inhomogeneous patches. It has application to any military activity near a surf zone that might require the use of acoustics. In particular, mine hunting and clearance and special warfare operations could benefit from knowledge produced by this experiment.

TRANSITIONS
This work will transition to MCM and special warfare application later in the project.

RELATED PROJECTS
This project is a joint effort between NRL and the Applied Physics Laboratory, University of Washington (APL/UW). NRL further engaged researchers from SIO, the Institute of Ocean Studies, British Columbia, Canada (IOS), the National Center for Physical Acoustics (NCPA), University of Mississippi, and the Applied Research Laboratory, Penn State University (ARL/PSU). The projects that were directly related to this effort included: APL/UW - Drs. Peter Dahl, Jeff Nystuen, Frank Henyey, and Dan Rouseff; various scattering and noise measurements and analyses and tomographic reconstruction. IOS - Drs. David Farmer and Svein Vagle; bubble population measurements and analysis and side-scan sonar imaging of bubble clouds. SIO - Drs. Ken Melville and Grant Deane and Eric Terrill; bubble population and coastal dynamics measurements and analyses. NCPA - Dr. Ali Kolaini; assistance with construction of the Delta Frame and selected noise measurements. IAP/RAS Dr. Alexander I. Khilko; development of emission and diffraction tomography algorithms for small-scale reconstruction of bubble clouds.

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